2.0 CONFIGURATION MANAGEMENT BASELINE

CM provides a model user with significant assurance that good software management practices are in place for that model. A controlled, logical process for the maintenance of a software program implies that users can report identified errors and suggest enhancements needed for their own studies to the controlling organization and have their recommendations receive serious consideration.

ESAMS is owned by the AFSAA, and is distributed through the SURVIAC. The developer of ESAMS is BDM. Under recent funding by the JTCG/AS, SURVIAC has been leading the ESAMS Users Group in the development of a simplified configuration control process, along with new configuration control and management procedures. SURVIAC also provides data sets representing many real-world systems, a technical point of contact, and a dial-up Bulletin Board System (BBS).

Details of the CM baseline assessment procedures can be found in the *SMART Project Verification, Validation, and Configuration Management (VV&CM) Process Description* [1], Section 2.3. Details of the assessment procedures for configuration baselines can be found in the *SMART Process Description*, Sections 2.3 and 3.3.

TABLE 2.0-1. Configuration Management Summary.

CM Characteristic	Status
Model Baseline Version	ESAMS 2.7
Sponsoring Organization POC	Air Force Studies and Analyses Agency AFSAA/SAG The Pentagon, Rm. 1D380 Washington, DC 20330 MAJ Greg Nowell voice: (703) 614-4247 fax: (703) 697-1226 email: nowell@afsaa.hq.af.mil
Supporting Organization POC	SURVIAC Wright-Patterson AFB, OH 45433 Technical POC Linda Hamilton (Booz-Allen & Hamilton/Dayton) voice: (513) 429-9509 fax: (513) 429-9795 email: Hamilton_Linda@bah.com Administrative POC Geri Bowling (Booz-Allen & Hamilton/Dayton) voice: (513) 255-4840 fax: (513) 255-9673 email: Bowling_Geri@bah.com

TABLE 2.0-1. Configuration Management Summary. (Contd.)

CM Characteristic	Status
Configuration Controlled	Yes
Documented CM Plan	Partial
Documented CM Procedures	Yes
Organized Users Group	Yes
Users Group Meeting Frequency	Quarterly

2.1 MODEL DESCRIPTION

The ESAMS is a digital computer simulation designed to determine the outcome of an encounter between a single airborne target and a surface-to-air missile (SAM) system. It provides a one-on-one framework in which to evaluate air vehicle survivability and optimization of tactics. Most Soviet SAM systems are modeled in ESAMS, as well as the primary activities of engagement, including sensor acquisition and tracking, missile flight dynamics, missile guidance and control, offensive/defensive countermeasures, and endgame (warhead/fuzing). Although the primary model results are probability of target kill and missile miss distance, the ESAMS user can examine details of other aspects of an engagement such as the missile flight path and guidance, and the effects of electronic countermeasures (ECM) and terrain.

ESAMS has been used in the following major analytical areas:

- attrition analysis
- tactics development
- survivability analysis
- countermeasure effectiveness
- support for force structure studies
- research and development of new systems

ESAMS is written almost exclusively in standard FORTRAN 77 (one GRACE-related subroutine is written in C) and consists of approximately 133,000 lines of code in 770 subroutines. ESAMS can be hosted on virtually any computer with a FORTRAN 77 and C compilers and approximately 30 MB of memory (for source code, object code, executables, and data). UNIX scripts and VMS command procedures for compiling and linking the code are provided along with sample input data files on the ESAMS distribution tape.

2.1.1 Model Mission

The primary missions of the model are (1) to assess the survivability of an airborne target against a SAM system and (2) to aid analysts in the study of SAM engagement phenomena to optimize tactics.

The secondary mission of ESAMS is to generate data needed for higher-order models to determine campaign-level results.

2.1.2 Model Functions and Characteristics

ESAMS simulates all weapon subsystems plus ECM for the following SAM systems:

SA-2	SA-6	SA-10	SA-14	SA-N-1	SA-N-7
SA-3	SA-7	SA-11	SA-15	SA-N-3	CADS-1
SA-4	SA-8	SA-12	SA-16	SA-N-4	
SA-5	SA-9	SA-13	SA-19	SA-N-6	

ESAMS is a one-on-one model with reactive and non-reactive flight path capabilities. Usually, SAM engagements are cued by a handoff from a search or early warning radar, but the model assumes that this cuing has already taken place, and so begins with the acquisition attempt by the target tracking radar. ESAMS allows only one radar cross section (RCS) table, so the user must select either the tracking radar or illuminator frequency to define RCS inputs. Missile motion is simulated with a five-degree-of-freedom (roll stabilized) model.

An air defense unit of the type represented by ESAMS is designed to protect a defended area from air penetration. The target is defined by its flight path (position, velocity, and orientation as a function of time), signature, vulnerability, and available countermeasures. In each ground-to-air interaction, the SAM site attempts to acquire and lock onto the target with its target tracking radar (TTR). The minimum signal required for acquisition, track establishment, and track as measured by the SAM radar is a function of many factors (e.g., atmospheric transmittance, multipath and clutter, terrain masking) and countermeasure interference.

For purposes of V&V under the SMART Project, the major components of ESAMS being addressed are the RF sensor and missile flyout, (endgame calculations have not been targeted). The RF sensor includes acquisition and tracking modes of the target tracking radar. The flyout includes launch/no-launch decision criteria, and missile flight dynamics and control.

RF Sensor Acquisition Mode. The ESAMS simulation starts with target acquisition. The sensor is “perfectly cued” to the target. In this mode the radar antenna is kept pointing directly at the flying target until its signal is detected above the noise and clutter levels. This does not correspond to a typical acquisition radar which may rotate in azimuth or electronically scan a certain acquisition volume. The ESAMS acquisition mode, therefore, determines the maximum range at which the target can be detected.

RF Sensor Track Mode. After successful acquisition of the target, the sensor then switches to the track mode of the tracking radar. The radar attempts to track the target in azimuth, elevation, and range, but can be affected by propagation phenomena and/or ECM. Normally, this mode generates a target lock-on which serves as the transition to the missile flyout portion of the simulation.

Missile Flyout. The flyout of a missile is preceded by acquisition or track establishment phases, or both. Countermeasures may be invoked during these phases. Before commencing its firing sequence, the site must meet specified launch criteria, including target range, velocity, and signal-to-noise ratio (SNR). Meeting these criteria, the site begins its firing sequence and launches a single missile. For a short time the missile boosts, then guidance begins. Ground or onboard commands are generated to guide the missile toward the target.

Missile guidance is updated until fuzing is initiated or until the simulation determines that an intercept is no longer possible. During missile flyout, the model provides for simulation of several user-selectable error sources, including thermal noise, clutter, multipath, target glint, scintillation, and various types of counter-measures.

Endgame: Upon fuzing, the model calculates the probabilities of kill from both warhead blast and fragmentation. The probabilities are based on warhead fragment characteristics, including fragment size and velocity, the aircraft vulnerability to the fragments, and the aircraft vulnerability to the warhead blast. Based upon these calculations, the model then computes the total probability of kill. An engagement ends upon successful intercept of the target or the missile flying past the target, impacting the ground, or self-destructing.

Flight Path: ESAMS has the capability to generate a simple flight path internally, to accept flight paths created by BLUEMAX II, an external flight path generator, or to accept flight paths generated from Time/Space Position Indicator (TSPI) data.

2.2 DEVELOPMENT HISTORY

ESAMS has had a long development history, as shown in Figure 2.2-1.

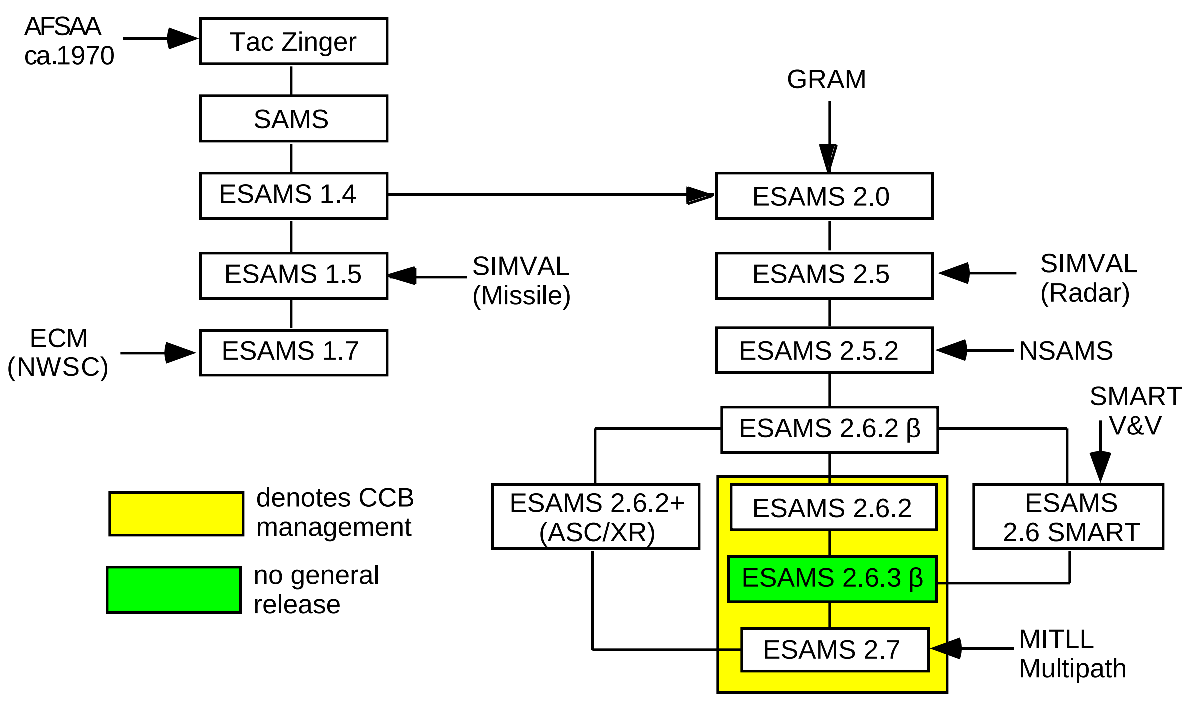

FIGURE 2.0-1. ESAMS Family Tree.

Features of the major versions shown in Figure 2.2-1 are summarized in the following paragraphs.

SAMS: ESAMS was originally developed from the 1970s-era Air Force Studies and Analyses code, TAC ZINGER. The original model was called SAMS; it was an upgraded version of the TAC ZINGER code and included the SA-11 SAM system.

ESAMS 1.4: BDM added a user-friendly input interface and implemented models of the SA-12, SA-13, and SA-14 SAM systems.

ESAMS 1.5: BDM added fixes supplied by users.

ESAMS 1.7: The Naval Weapon Support Center (NWSC) wrote code implementing chaff, flares, range gate pull-off (RPGO) jamming and other ECM [2]. BDM added these ECM functions, plus changes resulting from the Foreign Technology Division (FTD), now the National Aerospace Intelligence Center (NAIC) Simulation Validation (SIMVAL) Project for the SA-4 [3], SA-6 [4], SA-8 [5], and SA-11 [6].

ESAMS 2.0: BDM added the SA-10 SAM system and the terrain bounce ECM technique. They also installed their Generic Radar Assessment Model (GRAM) [7].

ESAMS 2.5: BDM added more Simulation Validation Project (SIMVAL) upgrades and the Ground Radar Clutter Estimator (GRACE) code. GRACE consists of four programs, the Triangular Terrain Generator, Site Mask Generator, RF Backscatter Estimator, and Environmental Data Manager.

ESAMS 2.5.2: BDM added more SIMVAL radar corrections [8,9] and the naval SAM systems.

ESAMS 2.6.2: This version was released in February 1994 and was the first version of ESAMS to be formally brought under configuration management.

ESAMS 2.6.3b: This beta version represented a significant revision of the code which primarily involved a change from time-stepped processing to waveform-driven processing in order to handle more general radar modes including, for example, PRF staggers. This version was used by AFSAA in several current studies including the Joint TacAir Electronic Warfare Study (JTAEWS) and was originally scheduled for release as version 2.6.3 in March 1995. Prior to the official release of version 2.6.3, AFSAA/CC directed that extensive code enhancements developed by ASC/XRE be integrated into version 2.6.3b, and the subsequent version was designated 2.7.

ESAMS 2.7: This version was released in October 1995 after approximately three months of beta testing by various organizations. It integrates the enhancements of version 2.6.3b, the ASC/XRE enhancements (ESAMS 2.6.2+), and some MIT Lincoln Laboratory MDR corrections to the multipath algorithms.

Significant new features of ESAMS 2.7 include the following:

- Waveform driven rather than time-stepped in order to facilitate multiple waveforms including PRF staggers as well as higher resolution ECCM modeling
- Updated intelligence data obtained from recent exploitations

- System-specific launch computers
- Improved guidance for SA-10 and SA-11
- Improved fuze modeling including semi-active fuzes
- Higher resolution end-game modeling based on triangular facet target model
- Improved chaff modeling including illuminated chaff
- Improved multipath based on work of MIT Lincoln Labs
- General code cleanup and run-time enhancements
- Updated documentation

Other Versions: ESAMS has been modified for inclusion in ACES/Phoenix by the U.S. Strategic Command (USSTRATCOM) and Air Force Operational Test and Evaluation Center (AFOTEC). Modifications to the model include construction of interfaces with other models so that single penetrator mission objectives can be analyzed. The work was performed by PRC and BDM.

An ESAMS 2.x model was integrated into the Penetrator model. This work was done by BDM under contract to AIL Systems. The effort interfaced ESAMS 2.x with the SUPPRESSOR model and others, so that few-on-few scenarios could be portrayed.

2.3 VERSION DESCRIPTION AND CURRENT STATUS

The elements listed below define the formal configuration of ESAMS, including software source code, documentation, and databases.

The current version is ESAMS 2.7 which was released in October 1995. New versions of the model are released quarterly, using identical version numbers. Sub-versions are distinguished by date of release. To date, over 60 copies of this version have been released by SURVIAC to authorized users.

Updated documentation was developed and released with version 2.7. Current documentation includes:

ESAMS Version 2.7 Security Classification Guide, AFSAA, October 1995 [10].

ESAMS Version 2.7 Installation Guide, SURVIAC-TR-96-007, October 1995 [11].

ESAMS Version 2.7 Analyst's Manual, BDM Federal, Inc., BDM/ABQ-95-0477-TR, October 1995 [12].

ESAMS Version 2.7 User's Manual, BDM Federal, Inc., BDM/ABQ-95-0475-TR, October 1995 [13].

ESAMS Version 2.7 Advanced User's Manual, BDM Federal, Inc., BDM/ABQ-95-0476-TR, October 1995 [14].

ESAMS Version 2.7 Threat Manual (U), BDM Federal, Inc., BDM/ABQ-95-0443-TR, SECRET/NOFORN, October 1995 [15].

ESAMS Version 2.7 Electronic Countermeasures (ECM) Manual (U), BDM Federal, Inc., BDM/ABQ-95-0474-TR, SECRET/NOFORN, October 1995 [16].

Model Databases: A design goal of ESAMS has been to provide missile system-specific data as separate data files. These data are read into three common blocks: RDRD for radar data, MSLD for missile data, and MULC for clutter data. In addition, generic target signature, vulnerability, and ECM data are distributed with the model and can be input to the TGTS, TGTV, and ECMD common blocks, respectively, when the appropriate run-time flags are set.

USSTRATCOM funded an effort to develop system-specific inputs for a variety of ECM systems including the ALQ-126, -131, -135, -161, -162, -172, -184, and the ALE-50, and these data files are currently distributed with ESAMS. Although these data were developed from the best available reference data, they carry no official endorsement and should be used with discretion.

SURVIAC maintains and distributes on a need-to-know basis additional signature and vulnerability data in ESAMS format. These include signature data for the A-10, C-130 and partial data for the F-16. Vulnerability data is available for the Short Range Attack Missile (SRAM), the Hound Dog missile, the Air Launched Cruise Missile (ALCM), the Tomahawk Land Attack Missile (TLAM), and the C-130, B-52, F-111, A-4, A-6, A-7, A-10, and F-16 aircraft.

The Air Force Information Warfare Center (AFIWC/SAC) created and maintains an ESAMS results database. The creation of this database was originally funded by AFSAA under the JTAEWS and contained model results for a variety of SAM/target combinations under several flight profiles. The database has been updated to contain similar model results obtained during version 2.7 beta testing. The database is Oracle based and allows on-line access to run summary information and target signature and vulnerability data. Distribution of the database data items is limited to government agencies and to contractors via their contract monitors on a need-to-know basis.

2.4 CHANGE PROCEDURES

CM of ESAMS has been problematic in the past, as evidenced by the ESAMS Family Tree (figure 2.2-1). However, this is being rectified by the design and implementation of a Configuration Management Plan, currently being drafted by SURVIAC under SMART Project funding. The goal of the CM Plan is to exercise control over distribution and maintenance of official ESAMS versions. Booz-Allen & Hamilton (BAH) operates SURVIAC for the JTCG/AS, a tri-service, DoD-sponsored organization and ESAMS is one of many models distributed through SURVIAC.

SURVIAC hosts ESAMS Users Group (EUG) and Configuration Control Board (CCB) meetings four times a year. The agenda covers problem areas, as well as analyses that have been completed using the model. Users finding errors are invited to fill out an ESAMS MDR and submit it to the configuration manager at SURVIAC.

BDM performs software maintenance and documentation of ESAMS as the support contractor for AFSAA/SAG (and recently, AFIWC). Bug fixes and model enhancements have been driven in the past by a number of different sponsors. However, under the new CM Plan, changes to the model are to be decided by the CCB.

2.4.1 Ownership

The owner of ESAMS 2.7 is the AFSAA, located at the Pentagon in Washington, D.C. ESAMS upgrades and enhancements have been sponsored by a number of different agencies over the years, including: AFSAA; AFOTEC; the Munition Systems Division (MSD/ENY) at Eglin AFB; the NWSC at Crane, Indiana; the Office of Naval Intelligence (ONI); and several DoD contractors. In a sense, each of these organizations could claim a share of the ownership. However, as used here, ownership will be associated with the organization having ultimate control over a particular version of the model.

2.4.2 Configuration Control Organization

CCB Composition: Members of the CCB are represented by the following organizations: SURVIAC, AFSAA/SA, BDM, MSIC, AFIWC, AFOTEC, Northrop, AF/SIMVAL, STRATCOM, RAND Corp., ONI, AATD, ASC, and NAWCWPNS. Members from BDM, Northrop and RAND are non-voting members.

CCB Working Groups:

- The CM Committee is drafting the ESAMS CM Plan.
- The Validation Committee is preparing a Validation Plan for ESAMS.
- The Verification Committee is writing a Verification Plan for ESAMS.

ESAMS Model Manager: MAJ Greg Nowell, AFSAA/SAG, (703) 614-4247.

Configuration Control Office: Ms. Linda Hamilton, SURVIAC, (513) 429-9509.

Configuration Administrator: Ms. Linda Hamilton, SURVIAC, (513) 429-9509.

2.5 USER SUPPORT FUNCTIONS

ESAMS Users Group: SURVIAC organizes EUG meetings approximately four times per year. At these meetings, SURVIAC discusses the current status of the model and plans for further development; users present ESAMS-related studies and applications; and specific changes recommended for inclusion in the baseline are reviewed and prioritized in open discussion.

ESAMS Help Line: The SURVIAC technical point of contact, Linda Hamilton, operates a call-in help line for ESAMS. Ms. Hamilton may be reached at (513) 429-9509.

ESAMS Bulletin Board Service: SURVIAC maintains a computerized BBS for all SURVIAC models. This service can be reached via (513) 255-9672. No internet connection is presently available. New users login as “new” and are granted limited access to the system; SURVIAC personnel then provide the new user with access keys dependent on the version(s) of the model the user currently has. The SURVIAC BBS has been set up especially to provide immediate support to the ESAMS Users Group.

2.6 ASSESSMENT AND IMPLICATIONS FOR MODEL USE

There is support available to ESAMS users in a number of areas. The previously confusing multiple baselines/configuration control structures are being unified and streamlined in a process not yet complete. The effect of these efforts, when completed, should be improved user confidence in analyses employing ESAMS.